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10 Frank W. Koleszar

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Research in cognition and perception has demonstrated that landmarks are useful for orienting travellers in a city. A landmark-based grid reference system for street maps is investigated as a replacement for the conventional system. Locations are referenced to a series of landmarks irregularly spaced throughout the

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Mental maps
Visual recall
Learning and memory
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Block 20: map, each of which is the center of a 2-by-2 grid cell. The cells, labelled by compass quadrant, vary in size depending on distance to adjacent landmarks. The landmark grid relates the map to the landscape, is easily used in a moving car while folded, references locations in the way that directions are given, and fosters familiarity with an area. Potential disadvantages include higher costs because of more drafting time and the research required to insure that depicted landmarks accurately reflect common usage by local residents. A sample of the general population tested the landmark and standard systems using navigation, measurement and visualization tasks. The landmark system allows higher accuracy in less time than existing grids, and assists map users in remembering spatial locations.

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INTRODUCTION

A large and continually increasing segment of the U.S. population moves each year, often to unfamiliar cities. In this situation maps are needed for navigation, wayfinding, and general acculturation. Street maps would seem to be important links in the acculturation process, as these maps portray urban landscape features necessary for

a mobile society: Interstate highways, through streets, shopping centers, residential areas, airports and hospitals.

This study reviews grid systems in general use, and suggests a reference grid that should assist in rapid, accurate location finding. The first map-use task generally encountered in finding a location on a street map is use of the reference grid. Although new approaches to cartographic design and relevance are abundant, little research in cartographic perception has been directed toward improving the design and use of the location reference system. Clearly the map grid contains a challenge for the cartographic profession to meet the needs of the non-academic map user through innovative methods.

REVIEW OF GRID SYSTEMS

A determination was made of the grid systems in general use in the U.S. by a sample survey of 120 street maps from every state and representing a wide variety of publishers. About ninety-two percent of the maps surveyed have some variant of the intersecting system: an overprinted grid with letter-number or number-number indices, or grid ticks with letters and numbers in the margins (Fig. 1). Using this system a street or other feature is located by finding the street name in the index, noting the associated letter-number combination and referring to the left and top margins of the map to select the cell where the designated row and column intersect.

The intersecting number-letter grid, hereafter referred to as the standard grid, has been variously referred to in literature as the Atlas Index System, or more recently as the Local Grid.[1] Muehrcke has recently criticized local grids as arbitrary--unable to relate locations from a

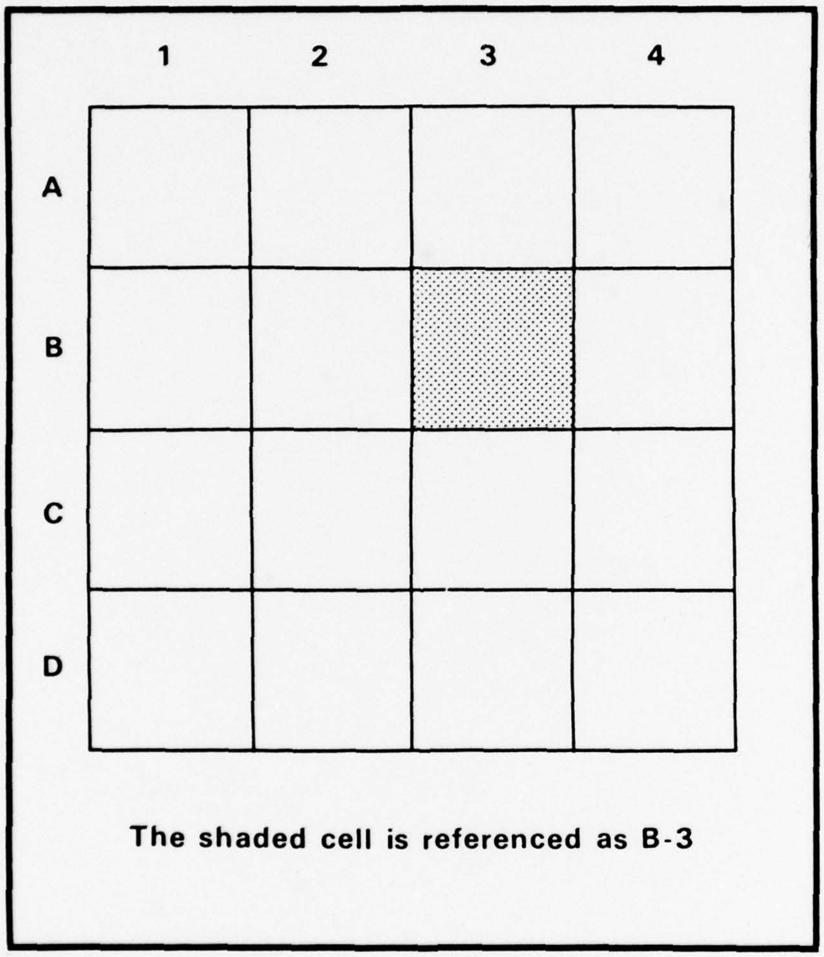


Fig. 1. Example of a standard grid.

map to the urban landscape, and from one map to another.[2] Local grids added after a map is made generally are not integrated effectively into the cartographic communication process, and as a result may actually hinder the transfer of spatial information to the user. Two additional disadvantages are apparent. First, the standard grid is awkward for use in a car. Once a feature is located and the map refolded to a convenient size, the grid numbers and letters are no longer visible. To remember the position on the map the map user might need to mark the location with a pencil, or hold his thumb constantly on the spot while driving. If the destination were located relative to one of a few readily visible and easily recalled map symbols, for example, in the cell "NE of the State Fairgrounds," one is less likely to require mechanical assistance. Moreover, the standard grid does not encourage the user to become more familiar with the area through use of the map reference grid; that is, the system commonly in use implicitly assumes that the map user is totally unfamiliar with the area and requires repeated, often maddening referrals to the index to find street locations even if these streets are in an area already at least vaguely familiar.

The geographic grid system, with spherical coordinates used in topographic maps and small scale navigation charts, is too complex for the immediate requirements of the map user and thus is impractical for street maps. An attempt to impose degrees, minutes and seconds on a street map undoubtedly would be met with disfavor. Plane coordinate systems also do not promote the tasks for which street maps are normally used.

Other grids used in street maps include the number-centered and letter-centered grids, both of which might seem to be improvements upon

the standard system (Fig. 2).[3] Grid cells are focused on points labelled with a number or letter in the center, and can easily be used when the map is folded while driving. Otherwise these grids have the aforementioned disadvantages of the standard grid.

The use of landmarks as reference points was proposed by Lynch, although not directly in the context of street map use. Lynch indicated that landmarks, as part of a reference cluster of visual cues, serve as signals to the traveller about his location and direction. As one becomes more familiar with a city, such landmarks can be relied upon more frequently for navigation and orientation.[4]

The American Foundation for the Blind has investigated landmark perception and use by the visually impaired, who of necessity use tactual landmarks as their primary means of navigation. A recent publication provides an illuminating statement of the utility of landmarks, and seems to codify their use in a visual context as well. Landmarks are used as reference points to establish and maintain directional orientation, to maintain distance relationships, to locate specific objectives, and to orient oneself on an area.[5]

The representation of folk landmarks is becoming increasingly commonplace. For example, "neighborhood maps" produced for a Washington, D.C. suburb highlight landmarks to introduce new and old residnets to the recreational and cultural possibilities inherent in their neighborhood.[6] A recent map of the Toronto waterfront highlights landmarks to publicize the area's recreational and developmental potential.[7]

Although landmarks have been used to help map readers visualize an area, little attention has been directed toward their usage in navigation and wayfinding. This study addresses the wayfinding question

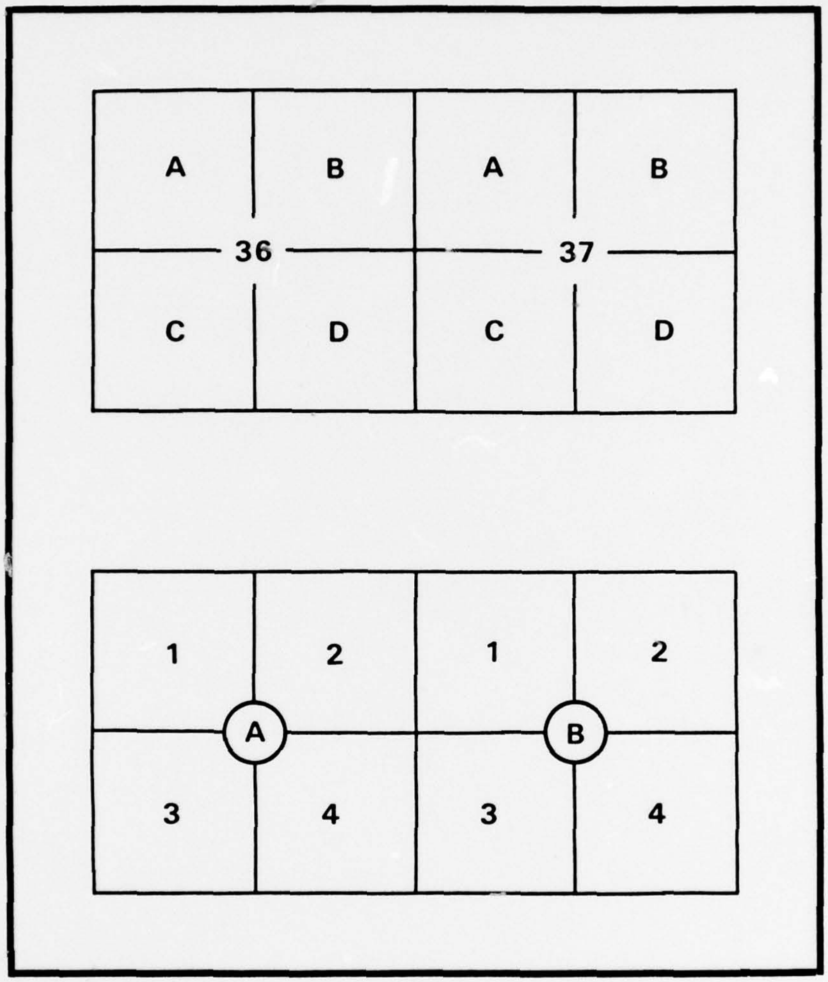


Fig. 2. Other grids in use.

directly, and compares experimentally a grid reference system based on recognized landmarks with that of a standard grid system. The intent of the subject-testing experiment is to evaluate the hypothesis that map users could more accurately and quickly perform tasks using a map with a grid based on landmarks, than with a standard grid. In addition, the landmark-based and standard grids are compared in a test relating grid design to recall of spatial relationships.

DEFINITION OF TERMS

Using a methodology somewhat similar to that of Gibson, the research question is formulated in terms of the concept of "efficiency."[8] Grid reference systems are compared on the basis of providing the most accurate information in the least amount of time. A convenient measure of efficiency is obtained for each respondant by dividing the number of correct answers by the subject's average response time. Accuracy and time are weighted equally because of the subjective determination that potential street map users would consider both of equal importance.

Because this study is concerned with the effectiveness of grids on maps of urban areas, the test employs large scale maps showing streets, shopping centers and other places of general interest. A road map, in contrast to a street map, primarily shows principal highways and provides only generalized road patterns within urban areas.

A landmark may be defined as an easily recognized place that can be portrayed prominently on the map and that is used as a reference point by local residents and businessmen. A landmark-based grid system references locations to a series of landmarks irregularly spaced throughout the map. A 2-by-2 subgrid is centered on each landmark and

varies in size depending on the distance to adjacent landmarks (Fig. 3). No area of the map lies outside a grid cell. Each quadrant is labelled NE, NW, SE, or SW as appropriate. Landmarks can be numbered from left to right, as well as from top to bottom, thus permitting a continuous, albeit meandering run. Locations are referenced by both landmark name and number and by the associated compass quadrant within the subgrid.

RESEARCH DESIGN

The statistical model tests grid-search efficiency as the continuous dependent variable together with the two grids and city maps as the independent categoric variables. The experimental design is a 2-by-2 randomized group completely confounded factorial design. This factorial design is determined by the two independent treatments tested, and the need to control for effects of memory: if different grids were shown to the same subjects, answers to the second grid would be influenced by what was remembered from the earlier map; yet if two groups of subjects each viewed a different grid, readability of the map grids could not be compared. The subjects were given a different grid-map combination during the second phase of the testing, hence the randomized group, completely confounded portion of the design (Table 1). Two groups of subjects were used: one group viewed the landmark grid on the first map and the standard grid on the second map, whereas with the other group the grid-map combinations were reversed. Each subject viewed two maps and two grid systems. Two subjects were randomly paired to complete one replication. Nineteen replications were made.

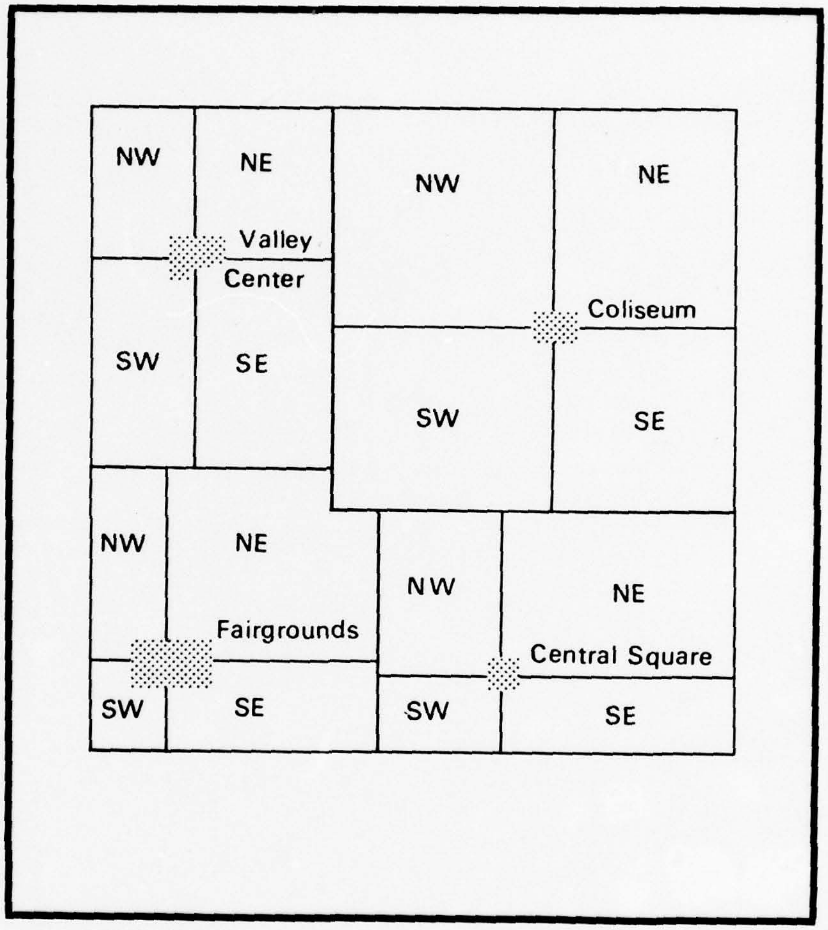
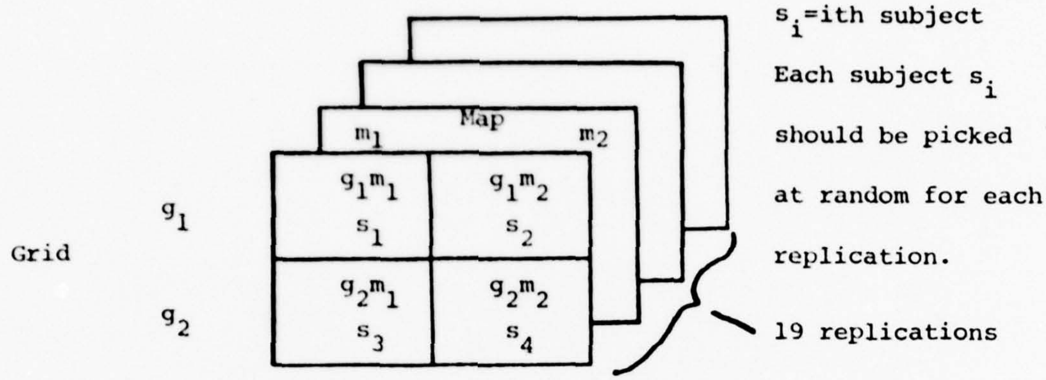


Fig. 3. Landmark-based grid.

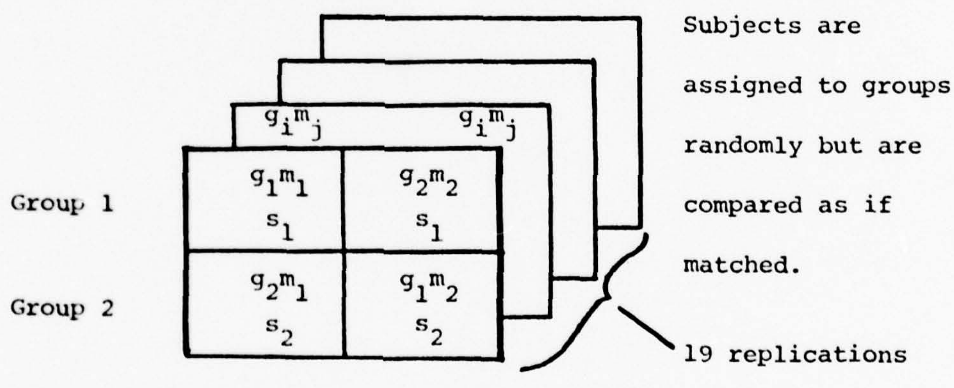
TABLE 1

EXPERIMENTAL DESIGN

Conventional 2-by-2 factorial design



2-by-2 randomized group completely confounded factorial design



Grid:

g_1 is landmark

g_2 is standard

Map:

m_1 is Spokane

m_2 is Phoenix

Source: Roger E. Kirk, Experimental Design: Procedures for the Behavioral Sciences. (Belmont, California, Brooks/Cole Publishing Co., 1968), p. 317.

MAP SELECTION AND PREPARATION

The test maps were chosen primarily for availability of printed maps, lack of overprinted reference grid, portrayal of fairly large cities, and legibility. In addition, the cities chosen were thought to be unfamiliar to as many subjects as possible in order to minimize bias because of a priori familiarity with the area. The maps selected were commercially produced street maps of Spokane, Washington, and Phoenix, Arizona.[9]

Landmarks were chosen for prominence on the map face and likely general interest. For example, a shopping center was chosen over a light metal fabrication plant even though the plant covered a larger area on the map. The highly subjective selection of landmarks had the benefit of an earlier pilot study. One grid cell centered on a particular landmark was drawn to coincide exactly with the standard grid for the same area so that test questions relating to the measurement task would be comparable in difficulty. Otherwise grid cells were made generally proportional in size to the amount of information contained therein: small cells in the central business district and its environs, and large cells on the rural fringe. Each landmark was highlighted with zip-a-tone, and given a number and a title in bold type (Fig. 3).

TEST SUBJECTS

The target population for this study was not restricted to any one socio-economic or demographic group such as college students. The subjects were chosen from a cross-section of residents in greater Syracuse, New York, based on sampling procedures similar to those used in market surveys.[10] A heirarchial, clustered random sample was drawn from census tracts stratified by income. Blocks were chosen with each

of the five census tracts by random sampling. Subjects were chosen within each block by going from house to house and asking occupants if they would participate in the study. Individuals willing to participate were assigned at random to one of two groups viewing different sets of map-grid combinations. Care was taken to insure that each group had twenty people.

Several possible sources of bias could not be controlled. Individuals who were not at home might often be away from home as a result of driving long distances because of their jobs. These individuals might be much more familiar with maps than the general public. Also, people who were at home but refused to participate might have an aversion to maps and therefore be less familiar with maps than the average person. The significance of these sources of bias was reduced somewhat because each subject was tested on both grids and both maps.

The personal characteristics of the groups were compared in terms of age, sex, education, occupation, map familiarity, frequency of general map use, and frequency of street map use. The subsamples were found to be generally similar; no significant difference was detected with the Student's t-test. The samples were almost evenly divided between males and females, and ranged in age from high school juniors to retired, with the greatest number in the twenty-to-forty age group. The range of educational backgrounds and occupations was equally as broad--from laborers with little education who could hardly read to white-collar workers with a college education. Minorities were represented roughly in proportion to their incidence in the local population.

TEST PROCEDURE

Each subject was tested individually at home on either the Spokane-Landmark and Phoenix-Standard combinations or the Spokane-Standard and Phoenix-Landmark grids. While the test was being set up, the individual was put at ease by asking about his or her personal background and feelings about using maps. Prior to testing, the use of each grid was explained in detail with examples. Each question then was read carefully to the subject from a prepared sheet to promote consistency in delivery and to allow time to interpret the question. To guard against differences in comprehension time, the location reference designator was announced only after a slight pause once the question had been read. Immediately upon hearing the location designator, the subject was to search and to point to the appropriate location on the map to indicate the answer. The search was timed with a stopwatch. To allay fears about this procedure, a trial run was made on a practice question prior to beginning the test.

The second map was then exhanged for the first and the procedure was repeated. Upon completion of the test, the subject was asked to pick the grid that he or she considered easier to use, as well as the grid that was liked better, and to give reasons for each choice.

Illumination levels varied widely, and a high percentage (twenty-five percent) of the people wore eye-glasses, occasionally with thick lenses to correct severe myopia. Despite these additional sources of experimental error, a subjective comparison of illumination levels between the two groups revealed very little difference between groups in the proportion in each of four categories: bright sunlight, diffuse daylight, tungsten bulb, and flourescent light.

In a telephone interview, approximately twelve to twenty-four hours later, the subject was asked to recall directions and spatial relationships from both map-grid combinations. Six respondents could not be polled because either their telephones were disconnected or they did not divulge their phone numbers at the initial testing.

TEST INSTRUMENTS

Perhaps the most difficult part of the entire experiment was determining map reading tasks common to users of street maps. Tasks were specified somewhat subjectively based on the experiences of Board and Gibson, and were adjusted by the results of a pilot test with undergraduate college students and suburban residents.[11] Types of tasks identified for testing included navigation, measurement, and visualization. Little weight was given the visualization task as a result of the pilot study, which indicated that street map users attempt to visualize an area very infrequently in comparison to the navigate and measurement tasks. Four test questions for each map pertained to navigating and locating, five to measurement and counting, and only one to visualization.

The questions chosen differed considerably in difficulty to prevent any spurious correlations based on easy questions (Appendix A).[12] Each question was scored individually for correctness and elapsed time. Accuracy and average time scores were combined into efficiency ratios (accuracy per unit time) for each group of tasks and for the test as a whole (Appendix B).

Questions testing recall linked map features the subjects had previously located by asking about directional relationships between features. Although features close to each other as well as those on

opposite sides of the test map (30x28cm) were used, the landmarks were never named or implied in the questions.

ANALYSIS OF RESULTS

Two-way analysis of variance was used to determine overall relationships, Student's t-tests were employed to measure the significance of various effects individually, and Chi-square analysis was used to relate personal characteristics to grid preference. Because efficiency scores are structured to increase as either more questions were answered correctly or less time was taken to answer the questions, a higher efficiency score should mean that one grid is easier to use than another. The distribution of efficiency scores was slightly skewed in the negative direction but was normalized with a square-root transformation (Fig 4A).

Student's t-test comparisons shows that, within each group of subjects, the landmark grid performed significantly better only for the Phoenix map (Table 2). Nonetheless, the mean efficiency score of the landmark grid paired with the Spokane map is higher than for the standard grid with either map. This result suggests that interaction is present; that is, the variables "grid" and "map" are not completely independent. The F-ratio for interaction is not statistically significant; whatever interaction might have been present does not affect the results of the two independent variables when acting together. In general, the landmark grid is the more efficient of the two, as demonstrated by an F-ratio of 4.05, which is significant at the five-percent level (Fig. 4B).[13]

A second objective of this study is to determine the extent to which the landmark grid can aid recall of feature locations and directional relationships. The related working hypothesis is that people will more

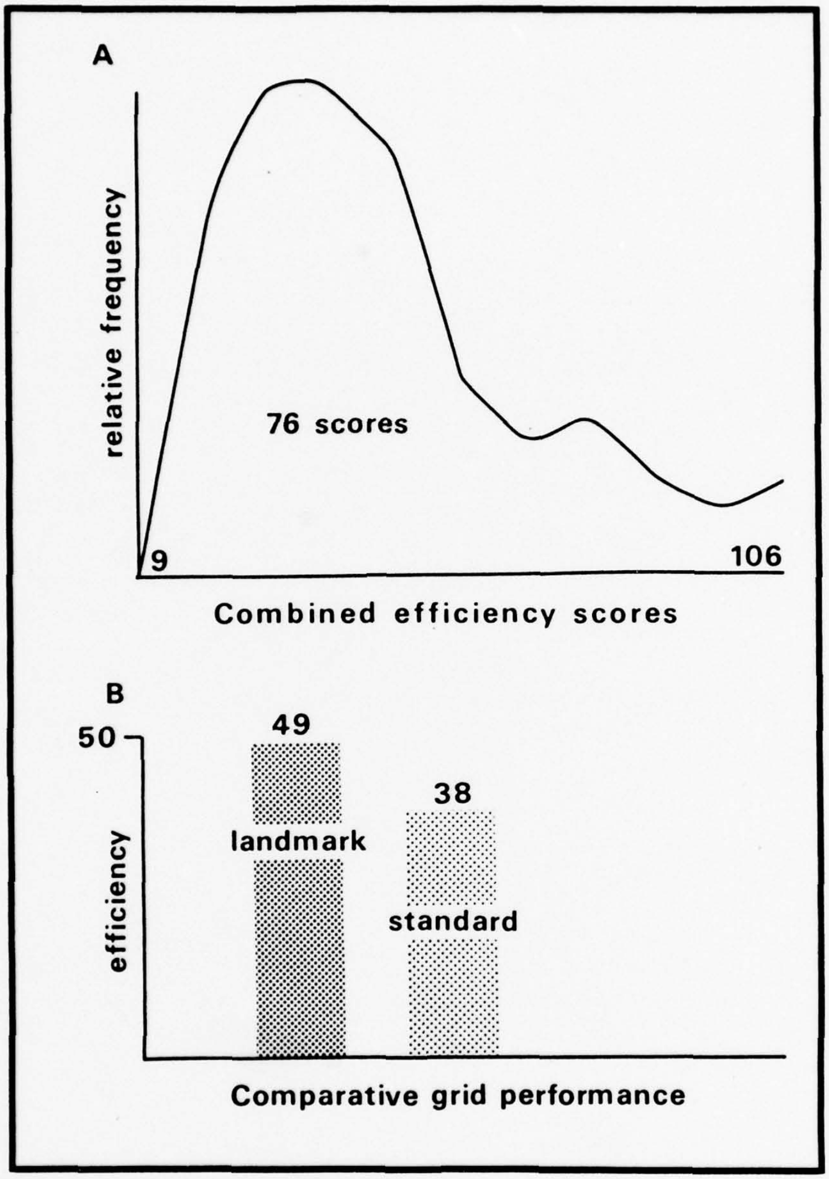


Fig. 4. Graphic summary of results.
A. Frequency distribution of combined untransformed efficiency scores.
B. Mean normalized efficiency scores for landmark and standard grids.

TABLE 2

SUMMARY TABLE FOR EXPERIMENTAL RESULTS

Map Efficiency Scores

		Map m_1 (Spokane)	Map m_2 (Phoenix)	mean
Grid	g_1 (landmark)	41.6	56.4	49.0
Grid	g_2 (standard)	39.4	37.1	38.2
	mean	40.5	46.7	43.6

See Appendix C for detailed statistical analysis.

easily remember features from the map with the landmark grid because of its association with a specific place or area--the landmark--than features ignored by an abstract number-letter grid. As tested in the present study, this hypothesis cannot be accepted: Student's t-tests for each city map as well as for both cities combined show that the grids do not differ significantly in their ability to assist the map viewer in recalling directional relationships.

The last item in each set of questions testing recall assesses the influence of the grid on the memorability of a prominent mapped feature about which no questions were asked on the earlier test. The features to have been recalled were the Spokane River for the Spokane map and the Interstate highway for the Phoenix map. The results of a t-test show no statistically significant difference between the two grids, although the mean efficiency score for the landmark grid was definitely higher than for the standard grid.

DISCUSSION

Results indicate that the landmark grid can make a street map easier to use by promoting a more accurate identification of location in a shorter time. As tested here, the landmark grid does not seem any more or less useful for recalling information than the standard grid.

In light of the above analysis several additional points relating to the use of the landmark grid are apparent. First, the size of the 2-by-2 grid surrounding the landmark is crucial. An attempt was made to insure that grid cell size was somewhat proportional to the information contained therein. Repeated observations of subjects' apparently aimless search patterns, however, indicates strongly that the relationship

between cell size and cell information must approximate more closely an inverse function: the more street names, buildings or other labels, the smaller the cell should be. Without this inverse relationship the subjects appeared to be uncomfortable and less thorough when searching a large grid cell. This is in accordance with the observation of Phillips, Noyes, and Audley.[14]

A phenomenon which could perhaps be called a "perceptual horizon" might be the factor controlling maximum grid cell size for a locality. A distance seems to exist beyond which the subject no longer associates the area with the landmark. Such a relationship is clearly evident in the study of landmarks by the visually impaired.[15] This perceptual horizon might considerably constrain the maximum size of a landmark grid cell, and might vary not only with areal familiarity but probably with race and socio-economic status as well.[16] Because the geographic distribution of significant landmarks throughout a region is often similar in density to other settlement locations, the perceptual horizon is likely to call for grid cells similar in size to those controlled by amount of information (Fig. 5).

In light of the dearth of research in this area, it is profitable to discuss the wider implications of landmark-based reference grids. Several advantages of the grid are apparent that have not yet been mentioned. First, and almost in answer to Muehrcke's allegation that local grids are unrelated to the urban landscape, the landmark grid provides a badly needed link between the street map and the ground. By referencing landmarks the map is more closely attuned to the way directions are given. For example, a driver asking for the location of Rowena Drive and receiving the reply: "It's about one mile west of

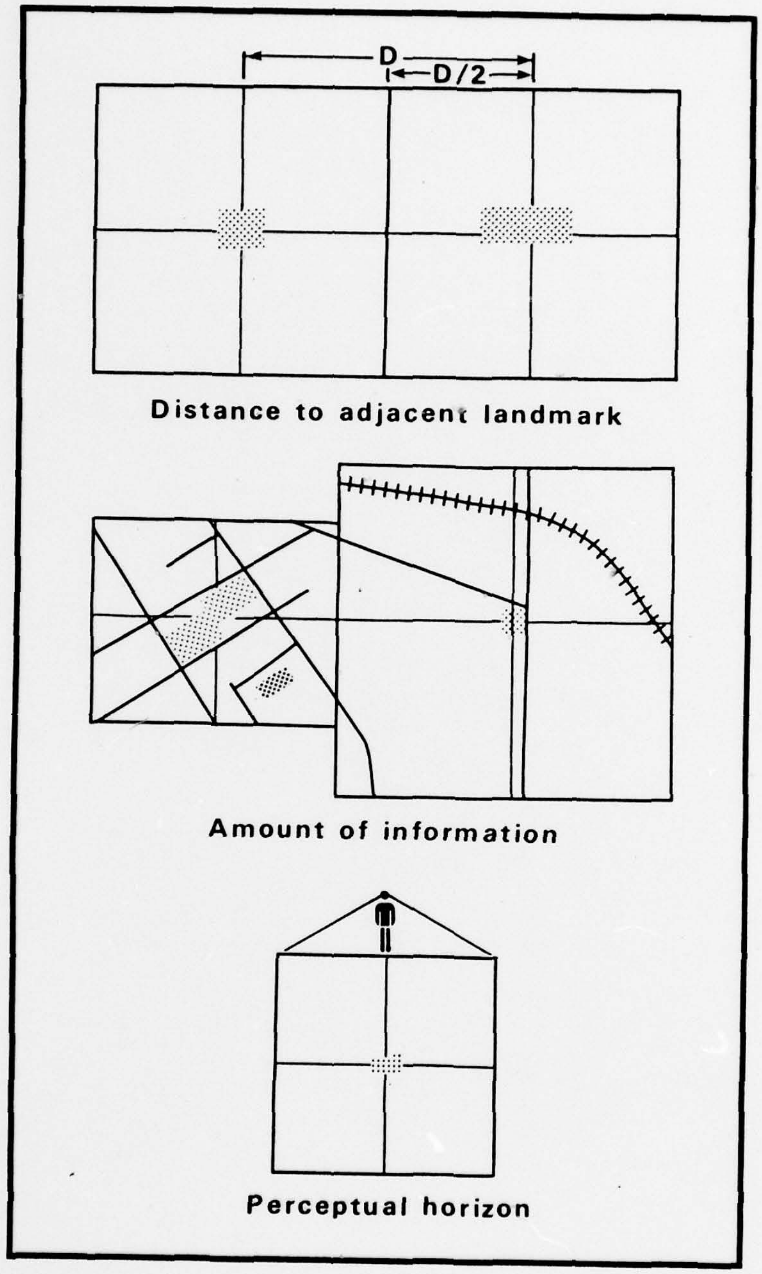


Fig. 5. Constraints on size of landmark grid.

Fairmount Fair Shopping Center, off the main highway," is better able directly to transfer the information to the map without the bothersome task of looking up Rowena Drive or Fairmount Fair in the index. Performance with the landmark grid for the urban area in which the map user lives and works might be much better than for unfamiliar areas used because of the greater meaning attached to familiar buildings and areas.

As a second major advantage, the landmark grid promotes familiarity with both the map and the ground the map depicts. An example can illustrate best this point. Upon learning that Elm Street is NW of the Coliseum, a later reference to Sinto Avenue's location as NW of the Coliseum is likely to call to mind the Coliseum's location with respect to Elm Street. Immediately a familiar mental image would flash to mind. By contrast, in 48 hours a reference to Sinto Avenue's location in cell B-3 of a standard grid most likely will elicit no reinforcement of learning, no cognitive response. Although the results of this experiment were not entirely in accord with this hypothesis, local residents familiar with Spokane and Phoenix might well have performed better than the Syracuse residents chosen for testing.

Several problems might surface in attempting to implement the results of this experiment in commercially produced street maps. A primary difficulty is cost. More man-hours of compilation and drafting are required to produce the irregular grid and label and index the compass quadrants than would be required to produce the simpler intersecting lines of the standard grid. Perhaps this economic drawback can be overcome by advertising the grid as a selling point of the map.[17]

The research effort in deciding which landmarks should be used as reference points might also be costly. Implicit in all previous

discussion was the assumption that any landmarks chosen would be widely perceived as landmarks by residents and businessmen who live and work in the area. Ideally all landmarks would be used habitually in the daily activities of the map user. To the extent that some landmarks are not used habitually, the map becomes less effective as a spatial communications tool. Open-ended interviews with two or three residents in a few key locations throughout an urbanized area, might obviate a more expensive random sampling strategy. The resulting landmark list probably would be just as effective, and cost less than a full-fledged rigorous survey, as would be appropriate for statistical analysis.

Getting the public to accept the new map grid might also be a problem. Map users are conditioned by existing maps and tend to prefer the road maps to which they are accustomed.[18] In this study, for example, the respondants had no clear preference for either the landmark or the standard grid. This apathy might well be overcome by the familiarity inherent in a landmark map of a local area.

Several subjects exhibited a feeling of uneasiness with the irregularity of the landmark grid. This apprehension made it difficult to locate the appropriate landmark, even after a demonstration and short practice session. Perhaps this reticence could be alleviated by the addition of a small inset overview map containing nothing more than the grid outlines and landmark names. But such a scheme would invite the same criticism as the standard grid: once the map was folded the overview index inset often would not be accessible. Another solution is possibly a semi-regular grid with uniformly spaced grid lines extending across the entire map in one direction (Fig. 6). Such a configuration would allow considerable latitude for placement of grid

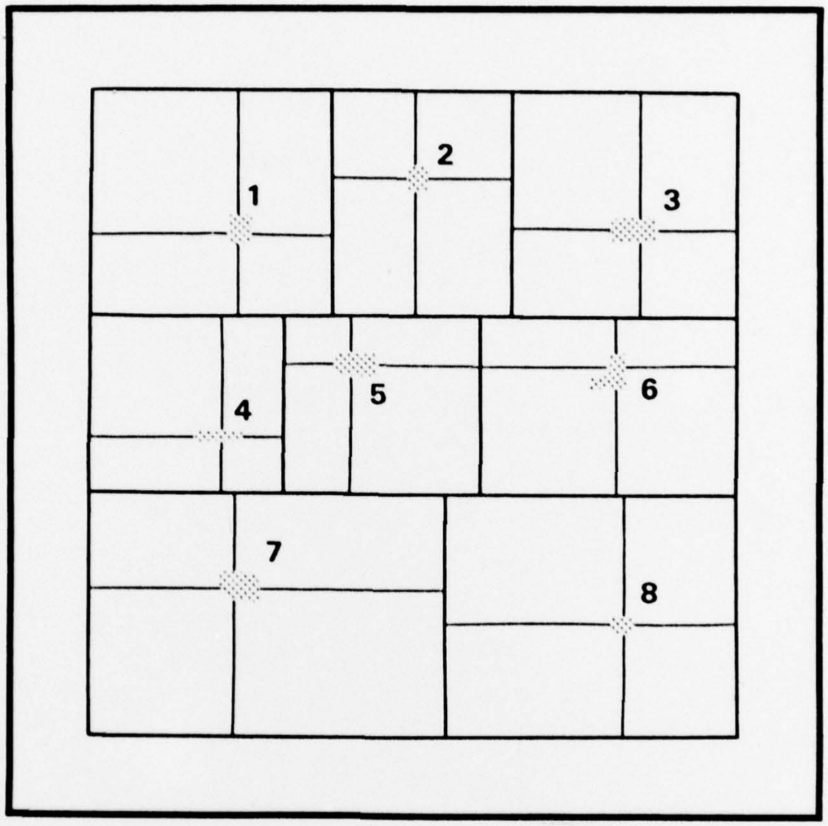


Fig. 6. Semi-regular landmark grid.

cells in the second direction and also give users a feeling of row (or column) continuity.

CONCLUSIONS

This study investigated whether the efficiency of street maps can be improved by a landmark-based grid reference system. Test results indicate that the landmark-based reference grid is more efficient in requiring less time for search-related tasks in relationship to the accuracy obtained. Landmark grids are potentially advantageous for use in moving vehicles, as well as for promoting areal familiarity. Drawbacks include cost, the research effort required, and the possible problems with public acceptance. The results of this study have possible wider implications to the field of perceptual cartography in general.

FOOTNOTES

[1]Everett C. Olson and Agnes Whitmarsh, Foreign Maps. (New York: Harper, 1944), p. 39. Phillip C. Muehrcke, Map Use. (Madison, Wisconsin: JC Publications, 1978), p. 87.

[2]Muehrcke, Map Use, footnote 1.

[3]Olson and Whitmarsh, Foreign Maps, footnote 1.

[4]Kevin Lynch, The Image of the City. (Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 1960), p. 101.

[5]Everett Hill and Purvis Ponder, Orientation and Mobility Teaching. (New York: American Foundation For the Blind, 1976), p. 5.

[6]"New Thing Art and Architechture Center's Sense of Neighborhood," Washington Post, August 13, 1972, Section H, p. 1.

[7]Roy H. Merrens, "The Ward Is My Oyster: Contemporary Cartography of Urban Amenities," Bulletin, Geography and Map Division, Special Libraries Association (1974), p. 7.

[8]Peter N. Gibson, "Toward a More Efficient Cartographic Style For Urban Area Planning Maps," Procedings of the American Congress on Surveying and Mapping, 37th Annual Meeting, February 27-March 5, 1977 Falls Church, Virginia, p. 10.

[9]Spokane Washington. (Chicago: Rand McNally & Co., 1973). Phoenix Arizona. (Chicago: Rand McNally & Co., 1975).

[10]Parker M. Holmes, Marketing Research: Principles and Readings. (Cincinnati: South-Western Publishing Co., 1966), p. 10.

[11]Christopher Board, "Map Reading Tasks Appropriate In Experimental Studies in Cartographic Communication," The Canadian Cartographer, Vol. 15 (1978), p. 11. Gibson, op. cit., footnote 8.

[12]Alastair Morrison, "Methods of Evaluating Motoring Maps," International Yearbook of Cartography, Vol. 15 (1975), p. 112.

[13]These results replicate the findings of a more limited study, with different questions and college students as subjects, which did not control for map effects.

[14]Richard J. Phillips, Elizabeth Noyes and R.J. Audley, "Searching For Names on Maps," Cartographer Journal, Vol. 15 (1978), p. 74.

[15]Hill and Ponder, Orientation and Mobility, footnote 5.

[16]F.C. Ladd, "Black Youths View Their Environment; Neighborhood Maps," Environment and Behavior, Vol. 2 (1970), p. 14.

[17]Somewhat similar to the "Visual Encyclopedia R," Trade Mark of the Marshall Pen-York Co., Syracuse, New York.

[18]Morrison, "Methods of Evaluating Motoring Maps," footnote 12.

APPENDIX A

TEST QUESTIONNAIRES

PERSONAL CHARACTERISTICS

NAME ______________________________ PHONE NO. ______________

1. GROUPID 1. Spokane LANDMARK, Phoenix STANDARD
   2. Spokane STANDARD, Phoenix LANDMARK

2. RESPNUM 01 to 40

3. CARD

4. SEX 1 M 2 F

5. AGE 1. 19 or under
   2. 20-40
   3. 41 or over

6. EDUCation level. Do you have a HS diploma? Higher?
   1. Did not complete HS
   2. HS Diploma or equivalent
   3. One or more years post-HS education

7. OCCUPation. What is your occupation?
   1. Self-employed
   2. Manufacturing
   3. Craftsman or foreman
   4. Finance, Real Estate, Insurance
   5. Manager or administrator
   6. Professional or technical

8. MAPFAM Based on your training and experience, how familiar are you with reading maps?
   1. Do not know how
   2. Slightly familiar
   3. Comfortable with using
   4. Very familiar

9. FREQUSE How often do you use maps of any kind?
   1. Never
   2. Very infrequently
   3. Occasionally
   4. Often
   5. Regularly

10. FSTREETU Frequency of street map use. How often do you use street maps?
   1. Never
   2. Very infrequently
   3. Occasionally
   4. Often
   5. Regularly

11. TYPEUSE What do you normally use street maps for?
   1. Never use street maps
   2. Visualizing - city layout
   3. Locating - shopping area, homes, government buildings
   4. Planning - a route to follow
   5. Following - a route
   6. Other

SPOKANE map: Landmark Standard

GROUPID

RESPNUM

CARD

TEST QUESTION #1. Please point to PACIFIC AVENUE. It is located: (SE of LUTHERAN SCHOOL-4/D2).

TEST QUESTION #2. Find BROWNE street. It is located: (SE of CANNON PARK-8/F4).

1. Find JULIA street. It is located: (SE of the RACE TRACK-6/D6).

2. Find BROOK street. It is located: (NW of CANNON PARK-8/E3).

3. Point to the POST OFFICE. It is located: (SW of the COLISEUM-5/D3).

4. Driving north along MONROE street, which prominant landmark would you come to first? This landmark could be in another grid cell but must be directly on the road. MONROE street is located: (NW of CANNON PARK-8/E3). [Federal Bldg]

5. Is there a GOLF COURSE located: (NE of COULEE INTERCHANGE-7/E1)? [yes]

6. Is there a SCHOOL located: (SE of LINCOLN PARK-9/F6)? [yes]

7. What is the LARGEST PUBLIC BUILDING located: (SE of the COLISEUM-5/D5)? [P.O. Terminal A]

8. Which street is closest to SACRED HEART HOSPITAL? It is located: (NE of CANNON PARK-4/D2). [8th Avenue]

9. How many PARKS or parts of parks are located: (SE of ROGERS HIGH SCHOOL-3/B5 and B6)? [4]

10. Which section of the city is probably the best place to shop? (SE or NE of the COLISEUM-5/C4 or D4). [SE/D4]

PHOENIX map: Standard Landmark

TEST QUESTION #1. Point to PIMA street. It is located: (E1/NE of the WELFARE DEPARTMENT-10).

TEST QUESTION #2. Point to ATLANTA Avenue. It is located: (G3/SE of CITY SERVICE CENTER-11).

1. Find HUBBELL street. It is located: (C6/SE of DOCTOR'S HOSPITAL-4).

2. Find INDIAN LANE. It is located: (A3/NW of PARK SHOPPING CENTER-3).

3. Find the DRIVER'S LICENSE Office. It is located: (B2/NW of the FAIRGROUNDS-5).

4. What prominent landmark would you come to first, when driving north along N 19TH AVE? It is located: (D2/NW of the STATE CAPITAL-7). [Coliseum]

5. Is there a CEMETARY located: (G6/NW of ESTEBAN PARK-14)? [no]

6. How many SCHOOLS are located: (B2 & A3/S of PHOENIX GENERAL HOSPITAL-2)? [2]

7. What is the largest PUBLIC BUILDING LOCATED: (C1/NW of HAYDN HIGH SCHOOL-6)? [naval reserve armory]

8. Which major street is the LIBRARY located on? It is located: (E3/NW of RIO SALADA PARK-12). [W. Yavapi]

9. ARIZONA BIBLE INSTITUTE is located at the corner of what two streets? It is located: (C1/NE of HAYDN HIGH SCHOOL-6). [31st & McDowell]

10. Which section of the city is probably an INDUSTRIAL AREA? (D6 or F6/SW of COUNTY GENERAL HOSPITAL-9 or SW of the AIRPORT-13). [F6/SW of airport]

POST-TEST QUESTIONNAIRE

1. QAPPROP Did you find the questions appropriate to what you would use a street map for?
    1. No, few of the questions
    2. About ½ of the questions
    3. Yes, most of the questions

    Why or why not?

2. EASIEST Which grid would you say is the easiest to use?
    1. Standard definitely easier
    2. Standard somewhat easier
    3. Both about the same
    4. Landmark somewhat easier
    5. Landmark definitely easier

    Why?

3. LIKE Which grid system do you like the best?
    1. Standard
    2. Landmark

    Why?

MEMORABILITY QUESTIONNAIRE

1 = correct
2 = incorrect

Recall the SPOKANE map. (Landmark/Standard)

1. Recall the two questions about JULIA street and BROOK street. What direction was JULIA street from BROOK street? NE, NW, SE, or SW? [NE]

2. Recall the question that referred to finding the POST OFFICE and another that asked about SACRED HEART HOSPITAL. What direction was SACRED HEART HOSPITAL from the POST OFFICE? NE, NW, SE, or SW? [SE]

3. Recall the question asking about the best section of the city to shop. What direction was the POST OFFICE from these shopping areas? E or W? [W]

4. Recall the question asking about the location of a GOLF COURSE and another a SCHOOL. What direction is the GOLF COURSE from the SCHOOL? N, E, S, or W? [W]

5. The Spokane River crosses through the city. In what general direction does it cross through the map area? N-S, E-W, NE-SW, or NW-SE? [E-W]

Recall the PHOENIX map. (Standard/Landmark)

1. Recall the two questions about HUBBELL street and INDIAN LANE. What direction is HUBBELL street from INDIAN LANE? NE, NW, SE, or SW? [SE]

2. Recall that there was a DRIVER'S LICENSE OFFICE plus a question that required you to find the LIBRARY. What direction is the LIBRARY from the DRIVER'S LICENSE OFFICE? NE, NW, SE, SW? [SE]

3. Recall the question asking about which section of the city is an industrial area, and the question asking about the ARIZONA BIBLE INSTITUTE. What direction is the ARIZONA BIBLE INSTITUTE from the INDUSTRIAL AREA? NE, NW, SE, or SW? [NW]

4. Recall the question about the counting of SCHOOLS and the largest PUBLIC BUILDING in the grid cell. What direction was the SCHOOL AREA from the LARGE PUBLIC BUILDING? NE, NW, SE, or SW? [NE]

5. There is an interstate highway crossing the Phoenix map. In what direction does it generally go? N-S, W-E, NE-SW, or NW-SE? [NW-SE]

APPENDIX B

TABLE OF RESPONDANT'S EFFICIENCY SCORES

Replication	Group	Respondant	Efficiency	
			$g_i m_j$	$g_i m_j$
1	1	1	32	41
	2	2	46	63
2	1	3	32	40
	2	4	52	101
3	1	5	63	60
	2	6	39	49
4	1	* 9	19	16
	2	10	24	32
5	1	11	27	46
	2	12	9	22
6	1	13	55	45
	2	14	18	26
7	1	15	26	28
	2	16	21	41
8	1	17	36	21
	2	18	46	54
9	1	19	34	41
	2	20	34	56

Replication	Group	Respondant	Efficiency	
			$g_i m_j$	$g_i m_j$
10	1	21	69	41
	2	22	21	36
11	1	23	12	24
	2	24	21	34
12	1	25	33	14
	2	26	48	59
13	1	27	70	38
	2	28	30	41
14	1	29	27	38
	2	30	22	26
15	1	31	27	38
	2	32	45	73
16	1	33	18	19
	2	34	79	93
17	1	35	105	58
	2	36	33	72
18	1	37	94	90
	2	38	78	88
19	1	39	12	16
	2	40	83	106

* Respondent numbers 7 and 8 were pairwise deleted.

APPENDIX C

DETAILED STATISTICAL ANALYSIS

Sources of variation	F-ratio	Probability	Is difference significant? Significant
Main effects	2.70	.074	No
Grid	4.05	.048	Yes
Map	1.36	.247	No
2-way interaction	2.59	.112	No

Comparison	Student's t	Probability	Significant
Landmark (Spokane) vs. standard (Phoenix)	1.13	.274	No
Landmark (Phoenix) vs. standard (Spokane)	6.52	.000	Yes
Landmark (Spokane) vs. standard (Spokane)	.27	.787	No
Landmark (Phoenix) vs. standard (Phoenix)	2.69	.011	Yes